Respiratory Medicine (2012) **106**, 549–556

Available online at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: www.elsevier.com/locate/rmed

All Danish first-time COPD hospitalisations 2002–2008: Incidence, outcome, patients, and care

Jesper Lykkegaard [a,*], Jens Søndergaard [a], Jakob Kragstrup [a], Jesper Rømhild Davidsen [a,b], Thomas Knudsen [a], Morten Andersen [a,c]

[a] *Research Unit of General Practice, Institute of Public Health, University of Southern Denmark, J. B. Winsløws Vej 9A, 1, DK-5000 Odense C, Denmark*
[b] *Department of Respiratory Medicine, Odense University Hospital, Sdr. Boulevard 29, DK-5000 Odense C, Denmark*
[c] *Center for Pharmacoepidemiology, Karolinska Institute, Karolinska University Hospital, SE-171 76 Stockholm, Sweden*

Received 25 August 2011; accepted 2 November 2011
Available online 23 November 2011

KEYWORDS
COPD;
Hospitalization;
Incidence;
Mortality;
Threshold;
Trend

Summary
Objective: This study aimed to investigate trends in first-time hospitalisations with chronic obstructive pulmonary disease (COPD) in a publicly financed healthcare system during the period from 2002 to 2008 with respect to incidence, outcome and characteristics of hospitalisations, departments, and patients.
Methods: Using health administrative data from national registers, all first-time hospitalisations with COPD in Denmark (population 5.4 million) were identified. Data based on the individual hospitalisations and patients were retrieved and analysed.
Results: During the period 2002 to 2008 the total rate of COPD hospitalisations decreased from 460 to 410 per 100 000 person years. Among persons above 45 years of age, the age- and sex-adjusted incidence rate of first-time COPD hospitalisations decreased by 8.2% (95% CI 5.0-11.2%). The inpatient mortality increased OR 1.16 (95% CI1.01-1.34) and the one-year mortality increased OR 1.12 (95% CI1.03-1.21). Concurrently, significant age- and sex-adjusted increases were found in use of intensive care, comorbidity, patient travel distance, bed occupancy rate of the receiving department, prior use of oral and inhaled corticosteroids, use of outpatient clinics and encounters in general practice, while length of stay and number of receiving hospitals decreased.
Conclusion: Decreasing rate of first-time COPD hospitalisations combined with shorter lengths of stay and increasing severity of cases indicates that the use of hospital beds for COPD exacerbations has been gradually restricted. This may be causally related to both the centralisation into overcrowded departments and the improved outside hospital treatment of COPD, also demonstrated in this study.

* Corresponding author. Tel.: +45 6550 3967; fax: +45 6550 3980.
E-mail address: jlykkegaard@health.sdu.dk (J. Lykkegaard).

0954-6111/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.rmed.2011.11.001

Introduction

COPD exacerbation is among the most frequent causes of hospitalisation.[1] In year 2000, the diagnosis accounted for the third most hospital bed days in England.[2] In Denmark, the annual number of patients hospitalised with COPD more than doubled from 1991 to 2001.[3] However, recent studies from developed countries report decreasing COPD prevalences,[4–7] and the rate of COPD hospitalisations in both the US[8] and Denmark[9] has been slightly decreasing since the late nineties.

In Denmark and most other developed countries tobacco consumption has been decreasing since the seventies,[10] and this may be the main reason why the rates of COPD hospitalisations have decreased. However, changes in the healthcare systems affecting the severity threshold for hospital admission and discharge of COPD patients may also play an important role which has not been investigated in previous studies.

In the last decade, the European healthcare infrastructure has been increasingly specialised into fewer units with larger patient volumes. These changes aim to provide cost savings from economies of scale and to improve quality of care. Evidently, mortality as well as length of stay can be lowered by providing COPD hospitalised patients with more specialist respiratory staff and improved high quality evidence-based care such as non-invasive positive pressure ventilation.[1,11,12] However, closing smaller hospitals and building fewer but larger ones mean that many patients must travel further to be hospitalised, while at the same time the number of acute care beds has been reduced throughout the developed world.[13] In Denmark, the total number of beds in medical departments decreased from 6970 in January 2002 to 6087 in December 2008.[14] Such changes may have increased the severity threshold of COPD hospitalisation in Denmark as well as in other countries with a similar trend within secondary healthcare.

This study aimed to investigate trends in first-time hospitalisations with COPD in a publicly financed healthcare system during the period from 2002 to 2008 with respect to incidence, outcome and characteristics of hospitalisations, departments, and patients.

Methods

Design

We conducted a register-based time trend analysis covering the whole Danish population (5.43 million in 2008[15]).

Setting

All COPD hospitalisations in Denmark are in public hospitals and occur either by referral from a general practitioner (GP) or in severe cases as a direct emergency admission. The Danish healthcare system is free of charge and with equal access for all citizens. Administrative data from all hospitalisations in Danish hospitals, including diagnoses classified according to International Classification of Diseases (ICD), have been recorded by the Danish National Patient Registry since 1977.[16] ICD 10th revision (ICD-10) has been used since 1994. Data are registered with the patient's unique civil registration number allowing individual level linkage to all national registers.[17]

Definition of first-time COPD hospitalisation

COPD hospitalisation was defined as any hospitalisation with either ICD-10 codes J41-44 (chronic bronchitis, emphysema, or COPD) as primary diagnosis or with J13-18 (pneumonia) or J96 (respiratory failure) as primary diagnosis combined with either J41-44 as one of the secondary diagnoses.[16]

Between January 1994 and December 2008 all subjects aged 45 years and above on the date of admission to hospital with COPD were identified. In order to determine whether it was a first-time COPD hospitalisation, we used individual 8-year look-back periods. A person was classified as prevalent from the first COPD hospitalisation until either death, migration, or the end of an 8-year period with no COPD hospitalisations. We linked the individual health administrative data with data from the Demographic Register in order to obtain dates of birth, death and migrations to or from Denmark. This register also provided numbers of the total Danish population by age and sex for the years 2002—2008. Age- and sex-specific monthly incidence rates of first-time COPD hospitalisations were calculated by dividing the number of first-time cases with the population at risk (the annual Danish population minus the prevalent cases at the beginning of the month in question). The age limit of 45 years was chosen because COPD is rare in younger people and we wanted to reduce the inclusion of misclassified asthmatics.[8] The 8-year look-back period and 7-year study period were chosen because ICD-10 classified data were only available from year 1994—2008 and we wanted to avoid the possibility of the same subject being regarded as first-time hospitalised twice in our study period.

Characteristics of hospitalisations and patients

From the Danish National Board of Health we annually retrieved names, addresses, medical specialities, and bed occupancy rates for all Danish hospital departments during the study period. We linked these data with the patient-specific data by use of admission year and department identification codes. Using the patients' civil registration numbers and dates of first-time COPD hospitalisations we retrieved the following register data on the patients: The Demographic Register provided home addresses of the patients in the year of hospitalisation, so that travel distance between the patients' homes and the receiving hospitals could be calculated. The Register of Medical Products Statistics comprises information on every medical product sold on prescription in Danish pharmacies since 1994. It provided dates and anatomical-therapeutic-chemical (ATC) codes on each drug sold to every patient. The Primary Health Care Database comprises individually linked information on every service provided by Danish GPs since 1990. It provided dates and service codes for each patient of all encounters in general practice.

The study received approval from the Danish Data Protection Agency (No. 2009-41−3337).

Analysis

For every annual cohort of first-time hospitalised COPD patients we calculated the proportion of inpatient deaths, and of deaths within one year from admission. We also calculated the average length of stay, the proportion of hospitalisations with stay on a ward classified as an intensive care unit, the proportion of hospitalisations more than 25 km from the patient's home address, the average Charlson comorbidity index (excluding COPD), and the average number of prior all-cause hospitalisations. The latter two were based on every patient's individual 8-year periods prior to their first COPD hospitalisation. The Charlson index was calculated by means of ICD-10 coded diagnoses from all in- and outpatient admissions.[18]

For one year prior to the patients' first COPD hospitalisation we calculated the patients' average number of encounters in general practice, and the proportion of patients having had spirometry in primary care, outpatient hospital treatment for COPD, and prescriptions of inhaled COPD medication and oral steroids. Finally we calculated average annual bed occupancy rates based on the report from each patient's receiving department in the year of reception.

Statistics

The 2002 and 2008 incidence rates of first-time COPD hospitalisations were compared using direct age- and sex-standardisation to the Danish 2008 population. Trends in first-time incidence rates were estimated by means of Poisson regression with calendar year as the primary independent variable. Trends in outcome and characteristics were estimated by means of either logistic regression models or linear regression models. Bootstrap estimations were used in the linear models due to variance heterogeneity of the residuals. In all models we adjusted for age and sex, and both the annual change and the total change from 2002 to 2008 were investigated. Coefficient plots and likelihood tests of fractional polynomials confirmed that it was reasonable to use year as a continuous variable without transformation. All analyses were performed using STATA Release 10.1 (STATACorp, College Station, TX, USA).

Results

During the period from 2002 to 2008 a total of 47 728 subjects were hospitalised 161 993 times with COPD in Denmark. Some 99.9% of the hospitalisations took place in public hospitals and 96% were admissions to departments of internal medicine.

The annual rate of COPD hospitalisations decreased from 460 to 410 per 100 000 person years, while the number of hospitals receiving COPD patients decreased from 70 to 58. Among the Danish population aged 45 years and above, the age- and sex-standardised incidence rate of first-time COPD hospitalisations decreased from 330 to 300 per 100 000 person years. The age- and sex-adjusted incidence rate ratio between 2008 and 2002 was 0.92 (95% CI 0.89−0.95), and analysing data for all the years, the adjusted decrease in the incidence of first-time hospitalisations was 1.2% per year (95% CI 0.8−1.7%) (Table 1). There was a large seasonal variation in both the total number of hospitalisations and the rate of first-time hospitalisations (Fig. 1).

The decrease in the incidence of first-time COPD hospitalisations was predominantly among males aged 60−79 years. In contrast, there were significant increases in the incidence among females aged 80 years and older (Table 1). In total, throughout the period around 46% were males, and the average age increased from 71.6 to 72.2 years (Table 2).

During the study period, the age- and sex-adjusted all-cause inpatient and one-year mortalities increased. Both inpatient and one-year age-adjusted mortality was higher in males than in females. The increase in inpatient mortality was predominantly among males, while the increase in one-year mortality was equal among the sexes.

Further age- and sex-adjusted trends in the characteristics of patients and hospitalisations were as follows: The use of intensive care units increased. So did the comorbidity of the patients both in terms of the Charlson index and the number of all-cause prior hospital admissions. The patients' prior diagnoses with cardiovascular disease, diabetes, cancer, and other diseases all increased substantially and gradually throughout the period.

The proportion of patients who travelled beyond 25 km to hospital more than doubled, while the average bed occupation rate of the receiving departments increased beyond fully occupied. Meanwhile the average length of stay decreased.

Regarding the year prior to the first COPD hospitalisation: The proportion of patients treated in outpatient hospital clinics for COPD increased. The proportion of patients who had a spirometry in primary care and the frequency of primary care encounters also increased except for home visits, which became fewer in the daytime while visits after hours remained constant. The proportions increased of patients who in the year prior to admission had redeemed at least one prescription for, respectively, inhaled long-acting beta-2 agonists, tiotropium, and corticosteroids (oral as well as inhaled). The proportion of patients who had redeemed a prescription for inhaled short-acting bronchodilators (beta2agonists or anticholinergics) decreased.

All the above trends were extremely significant, especially when analysing data for all the years instead of just comparing year 2002−2008 (Tables 1 and 2).

The number of first-time hospitalisations with ICD-10 codes J41-43 (chronic bronchitis or emphysema) as opposed to J44 (COPD) decreased more than the total decrease in first-time COPD hospitalisations (Table 2). Based on the 2002 hospitalisations, mean age, gender, mortality, comorbidity, use of intensive care, and encounters in general practice did not differ between these two groups, but compared to those coded with J44, patients coded with J41-43 were less often treated with inhalation drugs and less often treated for COPD in outpatient clinics. They were admitted to less crowded departments, which were less often specialised in internal medicine and to which they had to travel a bit further (Table 3). Patients coded with J13-18 (pneumonia) or J96 (respiratory failure) had a much

Table 1 First-time COPD hospitalisations in Denmark 2002 − 2008.

	2002			2008			Change 2002 − 2008	
	No. with new COPD	Population at risk	IR per 1000 years	No. with new COPD	Population at risk	IR per 1000 years	$IRR_{2008/2002age-\&\ sex-adj.}$	$IRR_{Annualage-\&\ sex-adj.}$
Females aged								
45−59 years	547	554,604	1.0	500	542,811	0.9	0.94(0.83−1.06)	0.99(0.97−1.00)
60−79 years	2314	443,831	5.2	2133	510,584	4.2	0.80(0.75−0.85)	0.97(0.96−0.97)
80 + years	829	140,690	5.9	1059	142,396	7.5	1.27(1.16−1.39)	1.04(1.03−1.05)
All ages	*3690*	*1,139,125*	*3.2^{Std}*	*3692*	*1,195,791*	*3.1*	*0.96(0.92−1.01)*	*0.99(0.99−1.00)*
Males aged								
45−59 years	441	564,963	0. 8	455	549,879	0.8	1.06(0.93−1.21)	1.01(0.99−1.03)
60−79 years	2051	388,047	5.3	1779	472,420	3.8	0.71(0.67−0.76)	0.95(0.94−0.95)
80 + years	767	68,945	11.2	867	74,866	11.6	1.05(0.95−1.15)	1.02(1.00−1.03)
All ages	*3259*	*1,021,955*	*3.3^{Std}*	*3101*	*1,097,165*	*2.8*	*0.87(0.83−0.91)*	*0.98(0.97−0.99)*
Overall aged								
45−59 years	988	1,119,567	0.9	955	1,092,690	0.9	0.99(0.91−1.09)	1.00(0.99−1.01)
60−79 years	4365	831,878	5.3	3912	983,004	4.0	0.76(0.73−0.79)	0.96(0.95−0.96)
80 + years	1596	209,635	7.6	1926	217,262	8.9	1.16(1.09−1.24)	1.03(1.02−1.04)
All ages	*6949*	*2,161,080*	*3.3 ^{Std}*	*6793*	*2,292,956*	*3.0*	*0.92(0.89−0.95)*	*0.99(0.98−0.99)*

Analysed using Poisson regression. Age- & sex-adjusted when appropriate. 95% confidence intervals in parentheses.
Abbreviations: IR, Incidence Rate; $IRR_{2008/2002}$, IR ratio comparing 2008 with 2002; IRR_{annual}, IR ratio for the increase of one calendar year calculated using all annual data during 2002−2008; ^{Std} Standardised on the Danish 2008 population.

higher mortality, comorbidity, and use of intensive care units than patients coded with J44 or J41-43.

Discussion

This study showed that during the period 2002 to 2008 the total number of COPD hospitalisations in Denmark decreased along with the adjusted rate of first-time COPD hospitalisations. Decreases were mainly among males aged 60−79 years while the rate among women older than 79 years increased. This gender difference probably reflects increases in female smoking relative to men in Denmark in the second half of the 20th century.[13] Likewise, after 30 years of decreases in the total Danish tobacco consumption,[10] the decreases in COPD hospitalisations might be interpreted as representing decreases in the incidence of the disease. However, changes in the other parameters included in this study led to a different conclusion.

Substantial increases were consistently found in several indicators of case severity, including mortality, comorbidity, use of intensive care unit, and prior use of oral corticosteroids. The combination of decreasing rates of hospitalisations and increasing severity of hospitalised patients indicates that the severity threshold of hospital admission increased,[19] so that less severe cases were more seldom admitted to hospital. It is not known whether this was because the GPs independently became better at treating exacerbations outside hospital and in selecting the correct patients for hospitalisation, or the development was forced by reductions in the number of hospital beds.

Length of stay is usually an indicator of severity. However, in the study period the number of hospitals and beds was reduced, the patients had to travel further, and the departments were increasingly overcrowded and all other factors point in the direction of increasing severity. Therefore, we believe that the decreases in length of stay resulted from a combination of increased restrictions in the use of COPD hospital beds, shortening length of stay by lowering the threshold for discharge, and a possibly improved efficacy inside hospitals, which may have resulted in shorter lengths of stay regardless of the disease severity among the hospitalised COPD patients. Importantly, the decreasing total number of COPD hospitalisations shows that the increased conduct of early discharge did not result in more readmissions.

While GPs treated increasingly severe COPD exacerbations outside hospital, the proportion of COPD patients medicated according to guidelines prior to their first hospitalisation improved substantially, perhaps explaining a reduction in the use of inhaled short-acting bronchodilators. There was also an improvement in the proportions of COPD hospitalised patients who had had a spirometry in general practice and who had treatment for COPD in outpatient clinics.

Our findings are interesting to other countries since international trends and characteristics of COPD hospitalisations seem to be similar. In both Denmark and the US, the rate of COPD hospitalisations increased rapidly during the nineties and then rather suddenly started to decline.[3,8,9,20,21] Similar to our findings, repeated UK audits in 2003 and 2008 have shown an increase in the average case severity of COPD hospitalised patients.[22] The inpatient mortality, age, gender, and length of stay found in these audits were almost identical to our findings.[1] A 2005 audit from Norway and Sweden showed the same length of stay as in our study, but slightly older age of the patients and an inpatient mortality of only 3.7%[23]. Furthermore, both the

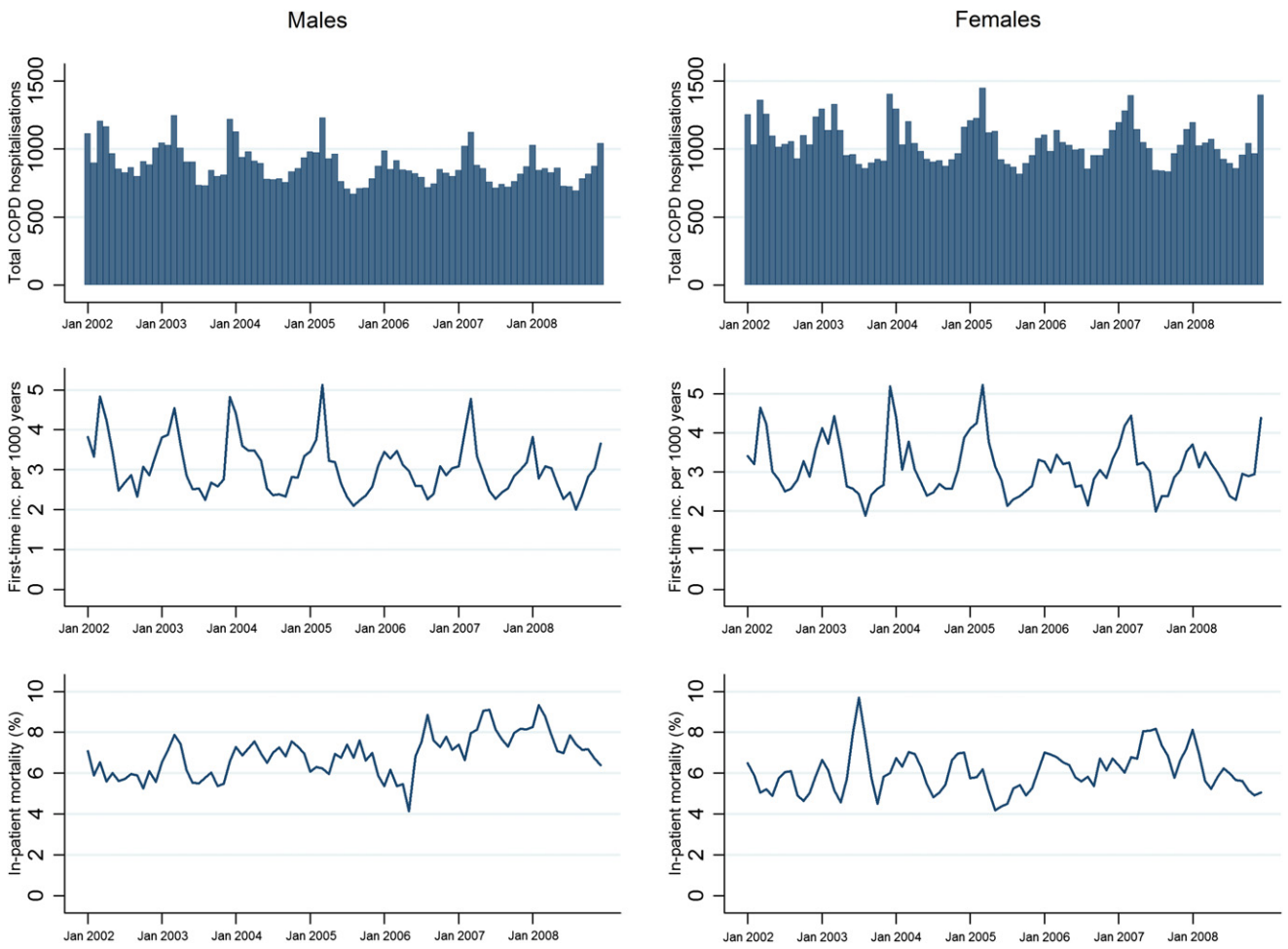

Figure 1 Total COPD hospitalisations, standardised incidence rate of first-time hospitalisations, and standardised inpatient mortality (running 3 month average). All standardisations are direct on the age distribution of the 2008 Danish population.

levels of mortality and the excess mortality in males found in our study are in accordance with a recently published large observational study from Canada.[24] In contrast to our findings, the inpatient mortality of COPD patients in Danish specialised pulmonary departments has probably improved during our study period.[25] However, a minority of Danish COPD hospitalisations is to specialised pulmonary departments and our study included all COPD hospitalisations and departments including those of no or other speciality, in which the development has evidently been different. The high completeness of our data is probably also a reason why the total rate of COPD hospitalisations in our study is higher than in studies from the US,[8,20,21] Norway, Sweden,[23] and France.[26] However, for decades the proportion of daily smokers has been much higher in Denmark relative to other developed countries, especially among women.[13]

Strengths and limitations

The ability of this study to exclusively identify all first-time cases and compare monthly changes in incidence rates with simultaneous changes in several characteristics is unique. The study covers every individual in a whole nation for 15 years using the same disease classification, ICD-10. Data on all hospitalisations, deaths and migrations were available and prospectively collected, avoiding recall bias and providing exact onsets for calculation of incidence. Access to COPD hospitalisation was equal and free of charge for all Danish citizens throughout the period and decisions to hospitalise were made by specialists in general medicine. There was no intermediate option between hospitalisation and primary care treatment which could bias the result.

Misclassification of the COPD diagnosis is a potential limitation of our study, since no spirometry data were available to secure the diagnosis and severity of cases. Some COPD diagnoses may be wrong and some COPD patients may have been misdiagnosed, for instance with pneumonia or cardiac failure.[16,27] However, the diagnoses obtained from the Danish National Registry of Patients were coded by the doctor in charge of the discharge and validated in a 2008 nationwide study which found a positive predictive value of 0.92 for COPD.[16] As suggested in the validation paper we added the codes J41-43 (chronic bronchitis and emphysema) to the COPD definition in order to minimize the influence of diagnostic drift. As shown in Table 3, there were big differences between patients included by different sets of diagnoses, but hospitalisations coded with J41-43 did not particularly differ compared to J44. The decrease in Danish COPD hospitalisations probably

Table 2 Trends in first-time COPD hospitalisations in Denmark during 2002–2008.

	2002	2008	Age- and sex-adjusted logistic regression		
No. first-time COPD hospitalisations	6949	6793	$OR_{2008/2002}$(CI95%)	OR_{annual}(CI95%)	P_{trend}
No. receiving hospitals	70	58			
	% of cases	% of cases			
Diagnosis code					
J44 prim.	67.8	62.2	0.79(0.74–0.85)	0.97(0.96–0.98)	<0.001
J13-18 prim. + J44 sec.	15.5	21.2	1.45(1.33–1.58)	1.05(1.04–1.06)	<0.001
J96 prim. + J44 sec.	5.9	9.9	1.76(1.55–2.00)	1.10(1.09–1.12)	<0.001
J41–43 prim.	7.7	4.9	0.61(0.53–0.70)	0.91(0.89–0.93)	<0.001
J13-18 prim. + J41–43 sec.	2.6	1.3	0.49(0.38–0.63)	0.89(0.86–0.91)	<0.001
J96 prim. + J41–43 sec.	0.5	0.5	0.98(0.60–1.61)	1.02(0.96–1.08)	0.53
Male gender	46.9	45.6	0.95(0.89–1.02)	0.99(0.98–1.00)	0.17
One-year mortality	23.2	25.9	1.12(1.03–1.21)	1.02(1.01–1.03)	0.001
Inpatient mortality	5.9	7.0	1.16(1.01–1.34)	1.03(1.01–1.05)	0.002
Stay in intensive care unit	1.2	1.7	1.42 (1.07–1.88)	1.09(1.05–1.13)	<0.001
Department of internal medicine	96.0	96.0	0.97(0.82–1.15)	0.99(0.96–1.00)	0.23
Private hospital	0.01	0.09	–	–	–
Travel distance > 25 km	10.5	21.9	2.43(2.21–2.68)	1.16(1.15–1.18)	<0.001
COPD outpatient 1 year prior	9.4	11.1	1.25(1.12–1.40)	01.04(1.03–1.06)	<0.001
GP spirometry 1 year prior	14.6	17.6	1.31(1.20–1.44)	1.05(1.04–1.07)	<0.001
Prescriptions 1 year prior					
Short-acting bronchodilators	81.3	58.2	0.60(0.56–0.64)	0.92(0.91–0.93)	<0.001
Long-acting beta2agonists	33.6	45.8	1.74(1.62–1.87)	1.10(1.09–1.11)	<0.001
Inhaled corticosteroids	49.2	54.5	1.26(1.17–1.34)	1.04(1.03–1.05)	<0.001
Tiotropium	4.0	27.2	9.57(8.39–10.93)	1.21(1.20–1.23)	<0.001
Oral corticosteroids	8.7	9.8	1.11(0.99–1.25)	1.04(1.02–1.05)	<0.001
	Mean	Mean	Age- and sex-adjusted linear regression		
			2008–2002(CI95%)	Annual(CI95%)	P_{trend}
Age/years	71.6	72.2	0.66(0.26–1.05)	0.13(0.08–0.18)	<0.001
Length of stay/days	8.8	8.4	−0.43(−0.83–0.03)	−0.08(−0.13–0.03)	0.003
No. prior all-cause hospitalisations	3.1	3.7	0.53(0.38–0.68)	0.09(0.07–0.11)	<0.001
Comorbidity (Charlson)	1.03	1.28	0.25(0.20–0.30)	0.04(0.03–0.05)	<0.001
Bed occupancy rate/%	99	102	2.5(2.0–3.1)	0.27(0.20–0.34)	<0.001
GP encounters 1 year prior					
Consultations	7.4	9.1	1.82(1.53–2.11)	0.31(0.27–0.35)	<0.001
Telephone consultations	11.9	13.1	0.99(0.48–1.51)	0.16(0.10–0.22)	<0.001
Home visits daytime	1.26	1.06	−0.30(−0.39–0.19)	−0.05(−0.06–0.03)	<0.001
Home visits out-of-hours	0.72	0.72	−0.03(−0.06–0.00)	0.00(−0.01–0.00)	0.22

Abbreviations: OR, Odds Ratio; CI, confidence interval; P_{trend}, *p*-value of an annual trend throughout the period; prim., primary diagnosis; sec., secondary diagnosis.

transpired in J41-43 coded hospitalisations because during the study period Danish pulmonologists and the Danish National Board of Health increasingly recommended the use of J44 instead of J41-43.[16,28] Furthermore, in our study period the funding of Danish hospitals was increasingly based on the type and number of diagnoses, creating an incentive for more precise coding. A diagnostic drift generated due to increased coding incentives would bias our findings towards underestimating the true decrease in COPD hospitalisations. In contrast, the increased coding incentives could explain some of the increase that we found in the average comorbidity index of COPD patients. However, COPD patients from recent years also have a higher number of previous all-cause hospitalisations, and we therefore believe that they actually have more comorbidity. Furthermore, the increase in mortality found in our study may be underestimated, because patients hospitalised late in the period most likely received an improved treatment, for instance by increased use of non-invasive positive pressure ventilation. The increase in this specific treatment may on the other hand partly explain the huge increase in the use of intensive care, because in most Danish hospitals this treatment required admission to an intensive care unit.

The combination of decreasing rate of first-time COPD hospitalisations and increasing severity might be explained by restriction in the use of the COPD diagnoses instead of restriction in hospitalisations of COPD patients. This is,

Table 3 First-time COPD hospitalisations in Denmark 2002 characterised according to diagnosis codes.

COPD defining diagnosis:	Chronic obstructive pulmonary disease (J44)			Chronic bronchitis or emphysema (J41-43)		
Primary diagnosis:	J44	Pneumonia (J13-18)	Resp. failure (J96)	J41-43	Pneumonia (J13-18)	Resp. failure (J96)
[Age] years	71.2	73.2	71.3	71.2	74.3	71.1
Male gender %	46.1	51.1	40.9	47.2	52.7	65.6
Inpatient mortality %	4.1	8.6	16.3	5.1	7.1	40.6
One-year mortality %	21.4	27.6	32.1	21.1	22.5	56.3
Intensive care unit %	0.5	1.2	10.0	0.4	5.5	12.5
Department of internal medicine %	97.7	95.2	91.5	95.9	94.5	96.9
[Department Occupancy rate]	99	101	105	98	98	99
Travel distance $>$ 25 km %	10.7	10.0	8.8	11.7	12.1	6.3
[Charlson comorbidity index]	0.99	1.16	1.28	0.92	1.12	1.16
COPD outpatient 1 year %	9.7	7.2	15.1	8.5	5.5	6.3
Inhaled corticosteroids 1 year %	50.1	49.2	49.4	40.4	42.9	28.1
Long-acting beta2agonists1 year %	35.4	31.3	32.3	25.8	27.5	31.3
Short—acting bronchodilators 1 year %	85.6	70.3	80.3	71.8	66.5	75.0
[No. GP consultations 1 year]	7.6	6.9	6.4	7.3	7.9	8.5
[No. GP telephone consultations 1 year]	12.0	12.0	11.0	12.2	11.6	12.3
[No. GP home visits daytime 1 year]	1.2	1.4	1.2	1.3	1.5	1.4
[No. GP home visits after hours 1 year]	0.7	0.8	0.8	0.8	0.7	0.7

Squared brackets indicate means. % indicates the proportion of cases in percent. Abbreviations: resp., respiratory; GP, general practitioner.

however, unlikely, since increasing awareness of COPD and economic incentives to detect and diagnose COPD has characterised our study period.[29] Furthermore, if COPD diagnoses were increasingly restricted to more severe cases, then the average length of stay should have increased. Instead it decreased, supporting the conclusion that it was in fact the use of COPD hospitalisation beds that was restricted.

Perspectives

COPD hospitalisations have become increasingly restricted to more severe cases. Therefore each COPD bed day probably demands more resources. Since this development seems to follow reductions in hospitals and beds for internal medicine it may be the same for many other diseases. Healthcare systems all over the world aim to provide high quality benefits at the lowest cost, and treating diseases like COPD in primary care instead of hospitals has in the recent years been a major focus of this endeavour.[30,31] In agreement with other studies,[32,33] this study has demonstrated improvements in the COPD treatment in Danish primary healthcare. These improvements may have led to postponement of admission referrals and made it possible to reduce the number of hospital beds. Another interpretation of our findings is that the increased restrictions in the use of COPD hospital beds were induced by the reduction in hospital capacity resulting in the increasingly overcrowded departments, which forced general practice to treat increasingly severe cases. A combination may be the case. Whether the restrictions in the use of COPD hospital beds have affected the overall quality of care for COPD patients is largely unknown, but the Danish Registry of Causes of Death reports that the age- and sex-standardised death rates from pulmonary diseases in our study period were decreasing.[34]

The international debate about the extent and character of changes in health and healthcare is often hampered by lack of documentation. Our study provides valuable data documenting changes within one of the most significant diseases.

Conclusion

Decreasing rate of first-time COPD hospitalisations combined with shorter lengths of stay and increasing severity of cases indicates that the use of hospital beds for COPD exacerbations has been gradually restricted. This may be causally related to both the centralisation into overcrowded departments and the improved outside hospital treatment of COPD, also demonstrated in this study.

Competing of interest

None.

Acknowledgements

The study was supported by a research fellowship to JL from the University of Southern Denmark, and by a research grant from the Governmental Region of Southern Denmark. None of the funders had a role in the study design, analysis, and interpretation of data, writing of the article, or

decision to submit the article for publication. We wish to thank Statistician Pia Veldt Larsen for statistical advice and Secretary Lise Keller Stark for proofreading the manuscript.

References

1. Price LC, Lowe D, Hosker HS, Anstey K, Pearson MG, Roberts CM. UK National COPD Audit 2003: impact of hospital resources and organisation of care on patient outcome following admission for acute COPD exacerbation. *Thorax* 2006;**61**:837–42.
2. Ham C, York N, Sutch S, Shaw R. Hospital bed utilisation in the NHS, kaiser permanente, and the US medicare programme: analysis of routine data. *BMJ* 2003;**327**:1257–61.
3. Juel K, Døssing M. *COPD in Denmark: the disease that kills 10 Danes every day [in Danish]*. Copenhagen: National Institute of Public Health; 2003.
4. Vasankari TM, Impivaara O, Heliövaara M, Heistaro S, Liippo K, Puukka P, et al. No increase in the prevalence of COPD in two decades. *Eur Respir J* 2010;**36**:766–73.
5. Soriano JB, Ancochea J, Miravitlles M, García-Río F, Duran-Tauleria E, Muñoz L, et al. Recent trends in COPD prevalence in Spain: a repeated cross-sectional survey 1997–2007. *Eur Respir J* 2010;**36**:758–65.
6. Gershon AS, Wang C, Wilton AS, Raut R, To T. Trends in chronic obstructive pulmonary disease prevalence, incidence, and mortality in Ontario, Canada, 1996 – 2007: a population-based study. *Arch Intern Med* 2010;**170**:560–5.
7. Bischoff EW, Schermer TR, Bor H, Brown P, van WC, van den Bosch WJ. Trends in COPD prevalence and exacerbation rates in Dutch primary care. *Br J Gen Pract* 2009;**59**:927–33.
8. Brown DW, Croft JB, Greenlund KJ, Giles WH. Trends in hospitalization with chronic obstructive pulmonary disease in the United States, 1990–2005. *COPD* 2010;**7**:59–62.
9. Lash T, Johansen M, Christensen S, Baron J, Rothman K, Hansen J, et al. Hospitalization rates and survival associated with COPD: a nationwide Danish cohort study. *Lung* 2011;**189**: 27–35.
10. Ekholm O, Kjøller M, Grønbæk M. *Health and disease in Denmark 2005. Development since 1987 [In Danish]*. Copenhagen: National Institute of Public Health; 2006.
11. Lightowler JV, Wedzicha JA, Elliott MW, Ram FSF. Non-invasive positive pressure ventilation to treat respiratory failure resulting from exacerbations of chronic obstructive pulmonary disease: Cochrane systematic review and meta-analysis. *BMJ* 2003;**326**:185–9.
12. Roberts CM, Barnes S, Lowe D, Pearson MG. Evidence for a link between mortality in acute COPD and hospital type and resources. *Thorax* 2003;**58**:947–9.
13. Organisation for Economic Co-operation and Development (OECD) health data october 2006, <www.oecd.org/dataoecd/20/51/37622205.xls>; [Date last accessed 25.08.11].
14. Danish National Board of Health – Hospital bed statistics, www.sst.dk/Indberetning%20og%20statistik/Sundhedsdata/Sengepladser.aspx; [Date last accessed 25.08.11].
15. Statistics Denmark, www.dst.dk; [Date last accessed 25.08.11].
16. Thomsen RW, Lange P, Hellquist B, Frausing E, Bartels PD, Krog BR, et al. Validity and underrecording of diagnosis of COPD in the Danish national patient registry. *Respir Med* 2011; **105**:1063–8.
17. Andersen TF, Madsen M, Jorgensen J, Mellemkjoer L, Olsen JH. The Danish National Hospital Register. A valuable source of data for modern health sciences. *Dan Med Bull* 1999;**46**:263–8.
18. Quan H, Sundararajan V, Halfon P, Fong A, Burnand B, Luthi JC, et al. Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. *Med Care* 2005;**43**: 1130–9.
19. Russo MJ, McConnochie KM, McBride JT, Szilagyi PG, Brooks AM, Roghmann KJ. Increase in admission threshold explains stable asthma hospitalization rates. *Pediatrics* 1999; **104**:454–62.
20. Kabir Z, Connolly GN, Koh HK, Clancy L. Chronic Obstructive Pulmonary Disease hospitalization rates in Massachusetts: a trend analysis. *QJM* 2010;**103**:163–8.
21. Mannino DM, Homa DM, Akinbami LJ, Ford ES, Redd SC. Chronic obstructive pulmonary disease surveillance-United States, 1971–2000. *Respir Care* 2002;**47**:1184–99.
22. George PM, Stone RA, Buckingham RJ, Pursey NA, Lowe D, Roberts CM. Changes in NHS organization of care and management of hospital admissions with COPD exacerbations between the national COPD audits of 2003 and 2008. *QJM* 2011; **104**:859–66.
23. Liaaen ED, Henriksen AH, Stenfors NA. Scandinavian audit of hospitalizations for chronic obstructive pulmonary disease. *Respir Med* 2010;**104**:1304–9.
24. Gonzalez AV, Suissa S, Ernst P. Gender differences in survival following hospitalisation for COPD. *Thorax* 2011;**66**:38–42.
25. Eriksen N, Vestbo J. Management and survival of patients admitted with an exacerbation of COPD: comparison of two Danish patient cohorts. *Clin Respir J* 2010;**4**:208–14.
26. Fuhrman C, Roche N, Vergnenegre A, Zureik M, Chouaid C, Delmas MC. Hospital admissions related to acute exacerbations of chronic obstructive pulmonary disease in France, 1998–2007. *Respir Med* 2011;**105**:595–601.
27. Iversen KK, Kjaergaard J, Akkan D, Kober L, Torp-Pedersen C, Hassager C, et al. Chronic obstructive pulmonary disease in patients admitted with heart failure. *J Intern Med* 2008;**264**: 361–9.
28. The Danish National Indicator Project, <www.nip.dk>; [Date last accesed 25.08.2011.
29. Blands J, Bælum L. *COPD – chronic obstructive pulmonary disease: recommendations for early tracking, following, treatment and rehabilitation [In Danish]*. 2nd ed. Copenhagen: Danish National Board of Health; 2007.
30. Department of Health. *Equity and excellence: liberating the NHS*. London: Department of Health; 2010.
31. Adams SG, Smith PK, Allan PF, Anzueto A, Pugh JA, Cornell JE. Systematic review of the chronic care model in chronic obstructive pulmonary disease prevention and management. *Arch Intern Med* 2007;**167**:551–61.
32. Ulrik CS, Hansen EF, Jensen MS, Rasmussen FV, Dollerup J, Hansen G, et al. Management of COPD in general practice in Denmark–participating in an educational program substantially improves adherence to guidelines. *Int J Chron Obstruct Pulmon Dis* 2010;**5**:73–9.
33. Lange P, Rasmussen FV, Borgeskov H, Dollerup J, Jensen MS, Roslind K, et al. The quality of COPD care in general practice in Denmark: the KVASIMODO study. *Prim Care Respir J* 2007;**16**: 174–81.
34. Danish Registry of Causes of Death. www.sst.dk/Indberetning%20og%20statistik/Sundhedsdata/Doedsaarsager/DSN_0.aspx; [Date last accessed 25.08.11].